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THE YOUNG COASTS OF ANNAM AND NORTHERN SPAIN*

By W. M. DAVIS

THE COAST OF ANNAM

An explanatory account of the coast of northern French Indo-China, with many illustrations of its influence on human conditions, is given in a recent interesting article in *La Géographie*.¹ The leading features are as follows: The mountainous border of the Gulf of Tonkin has for the most part an embayed shore line of subrecent or recent submergence, fronted by a shallow sea bottom, which may be inferred to represent a submerged piedmont fluviatile plain composed of detritus from the well-dissected backland: but the coast of Annam to the south of the great delta of the Song-koi, or Red River, is now simplified from the initial irregularity due to its subrecent submergence by two series of longshore beaches, one emerged to a height of three or four meters and composed largely of shells, the other at sea level and of a more sandy composition. Both series of beaches stretch in long curves, concave seaward, between salient spurs or hills that advance from the mountainous backland as headlands or islands. The salients are a little wave-cut at the level of the beaches. The lower beaches are in groups of two or three members at the same level, one prograded in front of the other; the outermost beach appears to be still growing seaward. The upper beaches are not so well developed as the lower ones, presumably because they were formed on the uneven sea bottom of first submergence, while the lower beaches had better opportunity for growth, as they were formed on the off-shore sediments of the upper beaches.

The former lagoon floors behind the higher beaches now appear as low plains, which may be inferred to extend inland into the bays and coves of the initial shore line of submergence, at the heads of which delta plains should stand at the same altitude as that of the emerged beaches. The low plains are drained by wandering rivers on their way from the mountains to the sea; the rivers are presumably entrenched in the former bay-head delta plains. The lower beaches enclose marshy lagoons. In striking contrast to the simplified coast of Annam, the coast of Tonkin, north of the great delta of the Red River, is still intricately embayed; the contrast is explained by assuming a recent and gentle tilting of the land on an axis trending northwest-southeast through the delta, whereby the earlier and greater submergence of the whole coast is continued and slightly increased to the northeast but is reversed into a slight emergence to the southwest.

* A continuation of the series "Notes on the Description of Land Forms" which appeared in the *Bull. Amer. Geogr. Soc.* as follows: Vol. 42, 1910, pp. 671-675, 840-844; Vol. 43, 1911, pp. 46-51, 190-194, 598-604, 679-684, 847-853; Vol. 44, 1912, pp. 908-913; Vol. 45, 1913, pp. 360-364, 518-521; Vol. 46, 1914, pp. 36-42, 524-527.

¹ E. Chassigneux: Plages soulevées dans le nord de l'Annam, *La Géographie*, Vol. 32, 1918, pp. 81-95.

HOW THE INHABITANTS LIVE

The natives of northern Annam occupy by tradition and therefore by preference the lower beaches and the marshy lagoons, where their villages are surrounded by hedges of bamboo; the marshes are cultivated in rice fields. Where the upper beaches are occupied, the dryness of their shell-bank soil, in which bamboo will not grow, leads to the use of reeds and thorny bushes for village hedges; here the rice fields of the marshy lagoons are replaced by plantations of mulberry trees, the leaves of which serve as food for silk worms. Wells on the elevated beaches take the place of tanks and pools in the lower marshes; the cemented shell stone, quarried from a small depth, is used for houses and pagodas. The mountainous backland is thinly populated.

DESIRABILITY OF PRESENTING GENERAL FEATURES FIRST IN A REGIONAL DESCRIPTION

The article from which the above abstract is made deserves praise because it enables the reader to visualize the landscape that it describes and to understand how the inhabitants live upon it. But the reader's task would have been easier if certain details, added above as inferences, had been explicitly announced. The reader's task would have been still more facilitated if the larger features of the region, which are placed first in the abstract, had not been postponed to the last pages of the article; for in that case the detailed accounts of the raised beaches which occupy the first pages of the article, where they stand unrelated to their natural attachments, could have been described after the larger features of the landscape to which they are manifestly subordinate. It is true that, to an observer on the ground, the elevated beaches may, for one reason or another, take precedence of other, larger features, particularly if they are selected as objects of special study and if shells are collected from them with the result of discovering that the species there preserved are the same as those still living in the neighboring sea, as is here the case; but when it comes to presenting the geographical results of such a study to readers at a distance, much may be said in favor of describing the general features of the region first, so that when the details are presented they may fall into their properly subordinate position, however great their importance may have seemed in a near-by view.

ABSENCE OF CORAL REEFS

It is singular that the headlands and islands of this torrid coast of submergence have not been fringed with coral reefs. The reason for the absence of reefs may probably be found in the shallowness of the adjoining sea floor, from which, as in the shallow Java Sea farther south, the sediments are swept landward to aid in the formation of beaches between the

headlands, thus making the headland waters prevailingly turbid; for corals will not thrive where sediments are swept about.

THE BAY OF SANTANDER

A recent article in the geological series of the *Trabajos del Museo Nacional de Ciencias Naturales* of Madrid,² like other articles in the same series, bears many marks of an awakening to modern morphological methods, which Spanish geographers have long disregarded. The Bay of Santander, one of several re-entrants on the northern, or Cantabrian, coast of Spain, is here analytically examined as to the geological history of its origin; the conclusions are set forth in such a manner that a concise explanatory account of the district may be composed from them. Although the author does not take this final geographical step, he might easily have done so if his object had not been gained without it, for he shows abundant familiarity with good physiographic procedure. His results may be summarized as follows:

The Cantabrian coast, composed of folded sandstones and limestones with east-west trends, slopes from a mountainous backland to a piedmont bench, 10 or 15 kilometers in width and 60 or 70 meters in altitude, which is interpreted as a platform of marine abrasion that was cut while the region stood at a lower level than now. Emergence then placed the platform at a greater altitude than it has at present, whereupon it was maturely dissected, so that, while a general view shows the residual uplands lying at accordant levels, many branching valleys are widely opened and the inter-valley hills have well-rounded slopes. A submergence then occurred, whereby the sea gained access to the maturely branching valleys and converted them into *rias*, or branching bays, some of which reached almost as far inland as the mountains; but this was so long ago that the inner branches of the bays are now largely filled with alluvium and converted into delta plains and tidal marshes, while the outer bays are shoaled and their shores are somewhat cliffed, leaving little valleys suspended above the present beaches. The process of *ria* filling is thought to have been aided by a slight emergence hereabouts, in contrast to which a continued submergence has prevented a corresponding aggradation of the larger *rias* in the Galician coast, farther west.

DESIRABILITY OF ADDITIONAL INFORMATION

Further information is desirable regarding certain items. First, the form of the spur ends where the mountains of the backland join the uplands of the piedmont bench should be examined; for if the bench be truly a platform of marine abrasion, cut back to a width of 10 or 15 kilometers, the steepened ends of the spurs ought to stand in line as parts of the

² J. Dantín Cereceda: Evolución morfológica de la Bahía de Santander, *Trab. del. Museo Natl. de Cienc. Nat.: Ser. Geol. No. 20*, Madrid, 1917.

series of cliffs that must have risen from the maturely retrograded inner border of the platform: but if the upland be a dissected peneplain, the spurs ought to decline gradually and their ends should not stand in line. Second, the possible occurrence of marine gravels on the least dissected inter-valley uplands should be searched for. Third, the relation of the valleys to the truncated strata needs consideration; for if the uplands truly represent a platform of abrasion, then the rivers which took possession of the presumably gravel-covered platform when it emerged would have incised their superposed courses without regard to the underlying hard and soft beds; while if the dissected upland be an uplifted peneplain, the valleys should show a considerable measure of adjustment to longitudinal weak belts. Fourth, the pattern of the outer coast, regarding which little is said, merits some attention; for, although the occurrence of low cliffs in the bays suggests the occurrence of higher cliffs on the outer coast, nothing is said about them.

GEOGRAPHICAL INSTEAD OF GEOLOGICAL FORM OF PRESENTATION

The results presented in this morphogenetic inquiry are set forth in historical order, in which the past tense of verbs, reproduced in the above abstract, is characteristically used. The results might be easily translated into geographical form in which the present tense is preferable, as follows: Santander lies on an outer bay-shore of a largely aggraded *ria*, which, like its neighbors, occupies a partly submerged valley system in an uplifted and maturely dissected platform of marine abrasion, 10 or 15 kilometers in width and 60 or 70 meters in altitude, at the base of the Cantabrian Mountains of northern Spain. Or: A belt of deformed sandstones and limestones, which rises in most of its width to form the Cantabrian Mountains of northern Spain, is continued along its seaward border in an uplifted and maturely dissected platform of marine abrasion, 10 or 15 kilometers in width and 60 or 70 meters in altitude, the valleys in which are occupied by branching *rias*, largely aggraded in their inner parts and somewhat shoaled by deposition and widened by cliffing in their outer parts: on the northern side of an outer bay in one of the *rias*, which opens northeastward and is imperfectly filled with alluvium, lies Santander.

As in all condensed explanatory descriptions, the qualitative statements regarding the Annam and Cantabrian coasts, given above, should be supplemented by detailed quantitative statements, in order to bring the local facts clearly before the reader: but the quantitative details are best apprehended by a mature reader if they are introduced by a concise qualitative summary.

THE MATURITY OF COASTS

The partly submerged coasts described in both of the articles above reviewed are stated by the authors to be in the stage of "maturity." It is gratifying to perceive in the use of this term that the systematic evolu-

tion of coasts, during which they pass through a well-defined succession of forms in orderly sequence, is recognized as of value in physiographic description; but it is questionable whether "maturity" is the best term by which to designate the stage of evolution reached by the coasts in question. An embayed coast must, if it stand still through an entire cycle of marine abrasion, very soon reach the stage of slight headland cliffing and partial bay filling; it must somewhat later reach the stage of complete headland truncation, when the steep cliffs, usually of increasing height, are cut back nearly or quite as far as the initial bay heads; and it will at a much later time reach the stage of far-retrograded, slanting cliffs of moderate height, when the slowly retreating shore line has receded well into the original interior highlands, which will then have lost a good share of their initial height by general degradation. A complete cycle of marine abrasion may thus be divided into early, advanced, and late, or young, mature, and old stages of evolution; and it is in this way that the marine cycle has been divided by those who have introduced organic terms for its description. In accordance with this scheme of nomenclature, the present stage of the Annam and Cantabrian coasts should be described as "young."

Whether a scheme of nomenclature which is based upon terms of organic growth shall be adopted for the description of inorganic land forms is perhaps still an open question; but until some other scheme is announced, it is desirable that authors who characterize slightly modified coasts of submergence as "mature" should give notice that they are departing from the meaning which has heretofore been given to "maturity" in the description of coastal forms and should at the same time define the other stages of coastal evolution which they propose to designate as "young" and "old."